Light harvesting in plants: principles and environmental trends

Alexander V. Ruban
School of Biological and Chemical Sciences, Queen Mary University of London, United Kingdom, a.ruban@qmul.ac.uk

Light harvesting in plants is largely an efficient process. The photosystems possess remarkable quantum efficiency, reaching 80% and 100% in photosystem II and I respectively. Hence, the primary photosynthesis starts with extremely economical primary processes – photon capture by antenna pigments, excitation energy transfer to the reaction centres and charge separation to initiate the reactions of the photosynthetic electron transfer. My talk will present a view on the organisation of a natural light harvesting network – the antenna of the photosystem II of higher plants. It explains the key principles of its design and the strategies of adaptation to light environment which have been evolved over millions of years. I argue that the high efficiency of light harvesting antenna and its control are intimately interconnected owing to the molecular design of the pigment-proteins it is built of. The minor group of pigments, xanthophylls, plays a central role in the regulation of light harvesting, defining its efficiency and thus ability to provide energy to photosystem II as well as protect it from excess light damage. Xanthophyll *hydrophobicity* (*h-parameter*) has been found to be a key factor controlling chlorophyll efficiency by modulating pigment-pigment and pigment-protein interactions. Xanthophylls also endow the light harvesting antenna with the remarkable ability to *memorise* light exposure – *a light counter* principle. Indeed, this type of light harvesting regulation displays a typical *hysteretic* behaviour, observed, for example, during electromagnetic induction of ferromagnetic materials. The molecular mechanism of antenna hysteresis is proposed to be based upon the control of pKa of proton-binding amonoacids via the enhancement in hydrophobicity of their environment (de-epoxidation and LHCII aggregation). Indeed, recent EM data revealed that the regulation of PSII requires a structural re-organisation of the grana membranes involving LHCII rearrangements around PSII core complexes and alterations in its *oligomeric state*, reduction in *protein mobility* and membrane thickness. The PsbS protein was found to act as a *catalyst* of this re-organisation, enhancing the mobility of chlorophyll-proteins. The photosynthetic antenna is thus a great example of how nature utilises the principles of physics to achieve its goal - an extremely efficient, robust, autonomic and yet flexible light harvesting.